



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04B 17/02	A2	(11) International Publication Number: WO 99/17476 (43) International Publication Date: 8 April 1999 (08.04.99)
<p>(21) International Application Number: PCT/FI98/00775</p> <p>(22) International Filing Date: 30 September 1998 (30.09.98)</p> <p>(30) Priority Data: 973850 30 September 1997 (30.09.97) FI</p> <p>(71) Applicant (<i>for all designated States except US</i>): NOKIA TELECOMMUNICATIONS OY [FI/FI]; Keilalahdentie 4, FIN-02150 Espoo (FI).</p> <p>(72) Inventor; and (75) Inventor/Applicant (<i>for US only</i>): SUONVIERI, Jukka [FI/FI]; Jenseninkatu 27 B 6, FIN-33610 Tampere (FI).</p> <p>(74) Agent: PATENTTITOIMISTO TEKNOPOLIS KOLSTER OY; c/o Kolster Oy Ab, Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).</p>		<p>(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>In English translation (filed in Finnish):</i> <i>Without international search report and to be republished upon receipt of that report.</i> </p>
<p>(54) Title: METHOD OF ADJUSTING FREQUENCY OF CELLULAR RADIO REPEATER</p>		
<p>(57) Abstract</p> <p>The invention relates to a method of adjusting the radio frequency of a repeater (302) in a cellular radio network. The repeater (302) amplifies radio signals (170) of a bi-directional radio connection between a base station (100) and a subscriber terminal (150) at least at one particular radio frequency. In accordance with the invention, the repeater (302) monitors the radio signals (170) transmitted by at least one base station (100). The repeater (302) automatically tunes to amplify the signals (170) of the particular radio frequency on the basis of information included in the radio signals (170) it has monitored. The monitored radio signals (170) include a control channel, for example a broadcast control channel BCCH, comprising information on the operating frequencies of the base station (100). Monitoring means (404) are preferably similar to the subscriber terminal equipment (150).</p>		

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METHOD OF ADJUSTING FREQUENCY OF CELLULAR RADIO REPEATER

FIELD OF THE INVENTION

The invention relates to a method of adjusting the radio frequency of a repeater in a cellular radio network, the repeater amplifying radio signals 5 of a bi-directional radio connection between a base station and a subscriber terminal at least at one particular radio frequency.

BACKGROUND OF THE INVENTION

Cellular radio networks use repeaters for covering shadow regions 10 of a base station. The shadow regions are caused by difficult terrain conditions, including mountains, buildings and tunnels. The repeater advantageously improves the quality of a radio connection between the base station and the subscriber terminal, since the acquisition and operating costs of the repeater, being simpler in structure, are lower than those of the actual base station. The repeater, as compared with the base station, provides a considerable saving particularly in telecommunication connections, because it does not 15 need expensive fixed transmission capacity which is required between the base station and a base station controller.

The repeaters are most commonly used in road tunnels, underground stations, car parks and other similar locations under ground from 20 where it is difficult or impossible to implement a direct radio connection to the base station. The use of the repeaters is more difficult in an open terrain, because a radio signal propagates over two paths between the base station and the subscriber terminal: directly and via the repeater. This brings about interference in the form of multipath-propagated signal components to the received 25 signal.

The repeater thus amplifies the signals of a base station that operates at a particular frequency. Each repeater must be adjusted to amplify radio frequencies used by a particular base station. When a large number of repeaters is involved, adjusting them to the correct frequency becomes a laborious 30 task that is prone to errors. Typically, a network administrator must perform frequency changes in the network in connection with the extension, increase of capacity and tuning of the network. When frequencies are reallocated, the repeaters within the area of each base station must also be modified to use the radio frequencies in accordance with a new frequency plan, for the repeaters 35 are channel selective and must therefore be configured to use the desired

frequencies. Broadband repeaters which do not need to be tuned to the desired frequency are also known in the field.

- In the prior art, the repeaters are manually adjusted to use the desired frequencies. In that case, a person in charge of maintenance travels to each repeater and adjusts, either mechanically or via a computer that is connected to the serial port of the repeater, the frequencies used by the repeater. In another approach, the person in charge of maintenance adjusts the frequencies by manual remote control. In that case, the repeater is arranged to receive information on the correct frequency by a radio modem, for example.
- 10 The radio modem may be a conventional GSM telephone, for example, with a modem card connected thereto. The repeater may also be arranged to receive information on the correct frequencies via a short-message service, in which case a GSM telephone is also connected to the repeater.

However, a problem in the above-mentioned arrangements is that they are manual operations involving extra work and being also extremely prone to errors.

BRIEF DESCRIPTION OF THE INVENTION

- An object of the invention is thus to provide a method and equipment implementing the method so as to solve the above-mentioned problems.
- 20 This is achieved by the method of the type presented in the introduction, which is characterized in that the repeater monitors the radio signals transmitted by at least one base station and automatically tunes to amplify the signals of the particular radio frequency on the basis of the information included in the radio signals it has monitored.

25 The invention also relates to a repeater in a cellular radio network, amplifying radio signals of a bi-directional radio connection between a base station and a subscriber terminal at least at one particular radio frequency.

The repeater of the invention is characterized in that the repeater comprises monitoring means for monitoring the radio signals transmitted by at least one base station, and adjustment means for automatically tuning to amplify the radio signals of the particular radio frequency on the basis of the information included in the radio signals it has monitored.

The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the idea that no special measures need be taken in order to change the frequencies amplified by a repeater. The repeater monitors information that is even normally transmitted by a base station, and concludes the frequency at which it should operate on the basis of 5 the information.

The method and system of the invention provide many advantages. A person in charge of maintenance does not need to take any measures in order to set the frequencies used by the repeater. The work contribution previously required in order to accomplish the task is no longer needed. In addition, 10 the risk of committing errors becomes considerably smaller. As compared with the prior art manual remote control, the solution of the invention does not involve extra costs.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in more detail by 15 means of preferred embodiments with reference to the accompanying drawings, in which:

- Figure 1 shows the structure of a cellular radio network;
- Figure 2 shows the structure of a transceiver;
- Figure 3 illustrates the use of a repeater;
- 20 Figure 4 shows the structure of the repeater of the invention;
- Figure 5 shows the structure of the channel unit of a repeater.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a typical structure of the cellular radio network of the invention. Only blocks essential to the description of the invention are included in Figure 1, but it is obvious to those skilled in the art that a conventional cellular radio network also comprises other operations and structures which do not need to be described in more detail in this context. The examples show a digital radio system using TDMA (Time Division Multiple Access), but the invention is suitable for use in all types of cellular radio networks using 30 channel selective repeaters, in different types of hybrid systems, for example, and also in analog radio systems.

A cellular radio network typically comprises a fixed network infrastructure, i.e. a network part, and subscriber terminals 150 that may be fixedly placed, vehicle mounted or portable terminal equipments. The network part 35 includes base stations 100. Several base stations 100 are controlled in a cen-

tralized manner by a base station controller 102 communicating with them. The base station 100 comprises transceivers 114. Typically, the base station 100 comprises 1 to 16 transceivers 114. In TDMA systems, for example, one transceiver 114 provides radio capacity for one TDMA frame, in other words, 5 typically for eight time slots.

The base station 100 comprises a control unit 118 controlling the operation of the transceivers 114 and a multiplexer 116. The multiplexer 116 assigns traffic channels and control channels used by several transceivers 114 to one transmission link 160.

10 The base station 100 transceivers 114 communicate with an antenna unit 112 that implements a bi-directional radio connection 170 to the subscriber terminal 150. The structure of the frames to be transmitted on the bi-directional radio connection 170, which is called an air interface, is accurately defined.

15 Figure 2 gives a more detailed description of the structure of a transceiver 114. A receiver 200 comprises a filter that blocks frequencies beyond the desired frequency band. Next, a signal is converted into an intermediate frequency or directly to a baseband, after which the signal is sampled and quantized in an analog-to-digital converter 202. An equalizer 204 compensates for interference caused by multipath propagation, for example. A demodulator 206 extracts a bit stream from the equalized signal, and the bit stream is transmitted to a demultiplexer 208. The demultiplexer 208 demultiplexes the bit stream from different timeslots into distinct logical channels. A channel codec 216 decodes the bit stream of the distinct logical channels, in 20 other words, it concludes whether the bit stream consists of signalling information to be transmitted to a control unit 214, or whether it is speech to be transmitted to a speech codec 122 of the base station controller 102. The channel codec 216 also carries out error correction. The control unit 214 carries out internal control tasks by controlling different units. A burst generator 228 adds 25 a training sequence and a tail to the data coming from the channel codec 216. A multiplexer 226 assigns a specific timeslot to each burst. A modulator 224 modulates digital signals to a radio frequency carrier. This is an analog operation required to be executed by a digital-to-analog converter 222. A transmitter 220 comprises a filter for narrowing down the bandwidth. Furthermore, the 30 transmitter 220 controls transmission output power. A synthesizer 212 generates the required frequencies for different units. The synthesizer 212 includes 35

a clock that can be controlled locally or in a centralized manner from elsewhere, from the base station controller 102, for example. The synthesizer 212 generates the required frequencies by a voltage-controlled oscillator, for example.

5 The structure of the transceiver can be further divided in the manner presented in Figure 2 into radio frequency parts 230 and into a digital signal processor 232 including software. The radio frequency parts 230 include the receiver 200, the analog-to-digital converter 202, the digital-to-analog converter 222, the transmitter 220, and the synthesizer 212. The digital signal processor 232 including software includes the equalizer 204, the demodulator 206, the demultiplexer 208, the channel codec 216, the control unit 214, the burst generator 228, the multiplexer 226, and the modulator 224.

10 The base station controller 102 comprises a group switching field 120, a transcoder 122 and a control unit 124. The group switching field 120 is used for speech and data switching and for connecting signalling circuits. The transcoder 122 converts different digital speech coding formats used between the public switched telephone network and the radio telephone network so that they are suitable for one another, for example from the 64 kbit/s format of the fixed network to some other format (for example 13 kbit/s), and vice versa. The 15 control unit 124 carries out call control, mobility management, gathering of statistical information, and signalling.

20 In the example of Figure 1, a connection is established via a mobile services switching centre 132 from the subscriber terminal 150 to a telephone 136 connected to a PSTN 134 (Public Switched Telephone Network).

25 An OMC (Operations and Maintenance Centre) controlling and monitoring the operation of the radio telephone system communicates with the mobile services switching centre 132. The OMC 132 is typically a relatively powerful computer including special software. The control may also focus on individual parts of the system, since data transmission connections between 30 different parts of the system can be provided with control channels required for transmitting control information.

35 In addition, the personnel installing the network and monitoring its use can utilize for example a portable computer including management software 140 (EM = Element Manager) for management of individual network elements. In the example of the figure, the device 140 is connected to a data transmission port in the control unit 118 of the base station 100 and it can

monitor and control the operation of the base station 100. It can examine and change the values of the parameters that control the operation of the base station, for example.

Figure 3 shows an example illustrating the use of a repeater. A repeater 302 is located within the coverage area of the base station 100. The repeater 302 uses an antenna 300 above ground level 306 for receiving a radio signal 170A transmitted by the base station 100 via an antenna 112. The repeater 302 amplifies the received radio signal 170A and transmits, via an antenna 304 that is located in a car park 308 under the ground level 306, an amplified radio signal 170B to the subscriber terminal 150 placed inside a parked car. The repeater 302 operates bi-directionally, i.e. the radio signal 170B received from the subscriber terminal 150 is also amplified, and the amplified radio signal 170A is transmitted to the base station 100. The repeater 302 and the base station 100 operate at the same radio frequencies, which is illustrated in Figure 3 by F1 indicating the radio frequency used by the radio signals 170A, 170B.

Figure 4 gives a more detailed picture of the essential parts of the structure of the repeater 302 of the invention. The repeater 302 has 1-N channel units 400, each being able to amplify radio traffic propagating via one base station 100 transceiver 114 in both transmission directions. Each channel unit 400 communicates with two antennas, the first antenna 300 being required for the radio connection 170A with the base station 100, and the second antenna being required for the radio connection 170B with the subscriber terminal 150. The operation of each channel unit 400 is controlled by a control unit. The bold line in Figure 4 illustrates the propagation of one connection through the repeater 400.

Figure 5 gives a more detailed picture of the structure of the channel unit 400. The channel unit 400 comprises two reception-transmission branches. A duplex filter 500A separating the transmission and reception frequencies from one another is located after the antenna 300 that provides the radio connection 170A to the base station 100. The upper reception-transmission branch shown in Figure 5 is composed of a receiver 502A, a power amplifier 504A and a transmitter 506A. Next there is a duplex filter 500B separating the transmission and reception frequencies from one another in an antenna 304 that provides the radio connection 170B to the subscriber terminal. The lower reception-transmission branch is composed of, similarly to the

upper reception branch, a receiver 502B, a power amplifier 504B and a transmitter 506B. Configured as in the example of Figure 5, the channel unit 400 thus receives, amplifies and transmits, using the upper branch, the signal 170A received from the base station 100 and performs, using the lower branch, the corresponding procedures to the signal 170 received from the subscriber terminal 150.

The number of channel units 400 depends on the required traffic capacity within the area covered by the repeater 302. Figure 4 shows N channel units, although considerably fewer units may be used; the radio repeaters 10 302 with one or two channel units 400 are used for covering low capacity areas.

Having described a typical structure of a cellular network, a typical operating situation of a repeater 302 and an example of the structure of the repeater 302, let us next study the operation of the invention. As already mentioned above, a major problem associated with the repeater 302 is how to configure it to use the same frequencies as the base station 100. This is a problem particularly in commissioning the network and, after the commissioning, each time modifications or extensions are made to the network to change the frequency planning of the network.

Figure 3 described how the base station 100 uses the frequency F1 for its traffic. In practice, more frequencies are used, but for the sake of clarity of the example, the description is limited to only one frequency. Let us also study Figure 4 showing that the repeater 302 comprises monitoring means 404 for monitoring the radio signals 170A transmitted by at least one base station. The radio signals 170A monitored by the repeater 302 comprise a control channel including information on the operating frequencies of the base station 100. In other words, this information is not intended for adjusting the frequencies of the repeater 302 as such, but it is system information of the cellular radio network, transmitted to the subscriber terminals 150 as broadcasts to 25 control the operation of the terminals. One of the control channels is a broadcast control channel BCCH including information on the operating frequencies of the base station 100. In the GSM 900 system, for example, the frequency information is transmitted as coded into a cell allocation table including information on 124 frequencies in 16 octets, the use of the frequency by the base 30 station 100 being indicated by the on/off state of a single bit.

- The table also includes a base station identity code BSIC identifying the base station 100. The repeater 302 identifies the correct frequencies on the basis of the BSIC, for information is set in the repeater 302 on the base station 100 whose frequencies it has to repeat. In other words, the repeater
- 5 302 monitors a predetermined base station 100. If the BSIC of the base station 100 is changed, the same change must also be made to the repeater 302 by manual remote control, for example. Another alternative is that the repeater 302 monitors the best receiving base station 100 of the correct operator and tunes to repeat its frequencies.
- 10 In accordance with the examples of Figures 3 and 4, the repeater 302 thus uses the monitoring means 404 for receiving the control channel signals 170A transmitted by the base station 100. It is possible to process the control channel signals 170A in two ways: they can be processed either in the monitoring means 404 or they can be transmitted to adjustment means 402 for processing. In processing, information on the frequency or frequencies at which the repeater 302 has to operate is decoded from the control channel signals 170A. In accordance with the example of Figure 3, the control channel signals 170A indicate that the repeater 302 must operate at the frequency F1. Next, the adjustment means 402 adjust the channel units 400 of the repeater
- 15 302 to repeat the signals at the frequency F1.
- 20 In practice, there are more frequencies that are repeated in use but only the frequencies that have changed are changed in channel units 400. The frequencies that remain unchanged do not need to be changed.
- 25 The invention is preferably so implemented that the monitoring means 404 are similar to the conventional subscriber terminal equipment 150. Depending on the type of subscriber terminal 150, slight modifications may be necessary so that the required information can be transmitted from the monitoring means 404 to the adjustment means 402.
- 30 A conventional GSM telephone is locked into the best receiving base station 100 of the correct operator, and, consequently, if it is desired that the telephone is locked into a particular base station 100, its operation must be somehow modified. Mobile telephone manufacturers typically provide their telephones with various test modes by means of which the desired property can be implemented easily.
- 35 The structure of the subscriber terminal 150 can be described by utilizing the description of the structure of the transceiver 114 of Figure 2. The

components of the subscriber terminal 150 are operationally the same as those of the transceiver 114. In addition, the subscriber terminal 150 comprises a duplex filter between the antenna 112, the receiver 200 and the transmitter 220, user interface parts and a speech codec. The speech codec is 5 connected via a bus 240 to the channel codec 216. However, the speech codec and the user interface parts are not needed in the monitoring means 404 of the invention. It is essential that the monitoring means 404 comprise the radio frequency parts 230 for monitoring the control channels, and the digital signal processor 232 including software, used for separating the information that is included in the control channels from the received signal 170A, 10 and possibly for decoding it, and at least for transmitting it to the adjustment means 402 which can also carry out decoding of the information.

The invention is preferably implemented in the adjustment means 402 by software, whereby the invention requires relatively simple modifications 15 in an accurately specified section in the processor included in the adjustment means 402. The repeater 302 may also be so implemented that the adjustment means 402 are distributed to each channel unit 400, whereby the operation of the invention is also distributed to the adjustment means 402 located in the control units 400.

20 Although the invention is described above with reference to the example according to the accompanying drawings, it is obvious that the invention is not restricted thereto, but it can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A method of adjusting the radio frequency of a repeater (302) in a cellular radio network, the repeater (302) amplifying radio signals (170) of a bi-directional radio connection between a base station (100) and a subscriber terminal (150) at least at one particular radio frequency, **characterized** in that the repeater (302) monitors the radio signals (170) transmitted by at least one base station (100) and automatically tunes to amplify the signals (170) of the particular radio frequency on the basis of the information included in the radio signals (170) it has monitored.
- 10 2. A method as claimed in claim 1, **characterized** in that the radio signals (170) monitored by the repeater (302) comprise a control channel that includes information on the operating frequencies of the base station (100).
- 15 3. A method as claimed in claim 2, **characterized** in that the control channel is a broadcast control channel BCCH.
4. A method as claimed in any one of the preceding claims, **characterized** in that the repeater (302) monitors a predetermined base station (100).
- 20 5. A method as claimed in any one of the preceding claims, **characterized** in that the repeater (302) monitors a best receiving base station (100).
- 25 6. A repeater (302) in a cellular radio network, amplifying radio signals (170) of a bi-directional radio connection between a base station (100) and a subscriber terminal (150) at least at one particular radio frequency, **characterized** in that the repeater (302) comprises monitoring means (404) for monitoring the radio signals (170) transmitted by at least one base station (100), and adjustment means (402) for automatically tuning to amplify the radio signals (170) of the particular radio frequency on the basis of the information included in the radio signals (170) it has monitored.
- 30 7. A repeater as claimed in claim 6, **characterized** in that the radio signals (170) monitored by the monitoring means (404) comprise a control channel including information on the operating frequencies of the base station (100).
- 35 8. A repeater as claimed in claim 7, **characterized** in that the control channel is a broadcast control channel BCCH.

9. A repeater as claimed in any one of claims 6 to 8, **characterized** in that the monitoring means (404) monitor a predetermined base station (100).
10. A repeater as claimed in any one of claims 6 to 9, **characterized** in that the monitoring means (404) monitor a best receiving base station (100).
11. A repeater as claimed in any one of claims 6 to 10, **characterized** in that the monitoring means (404) are similar to the subscriber station equipment (150).

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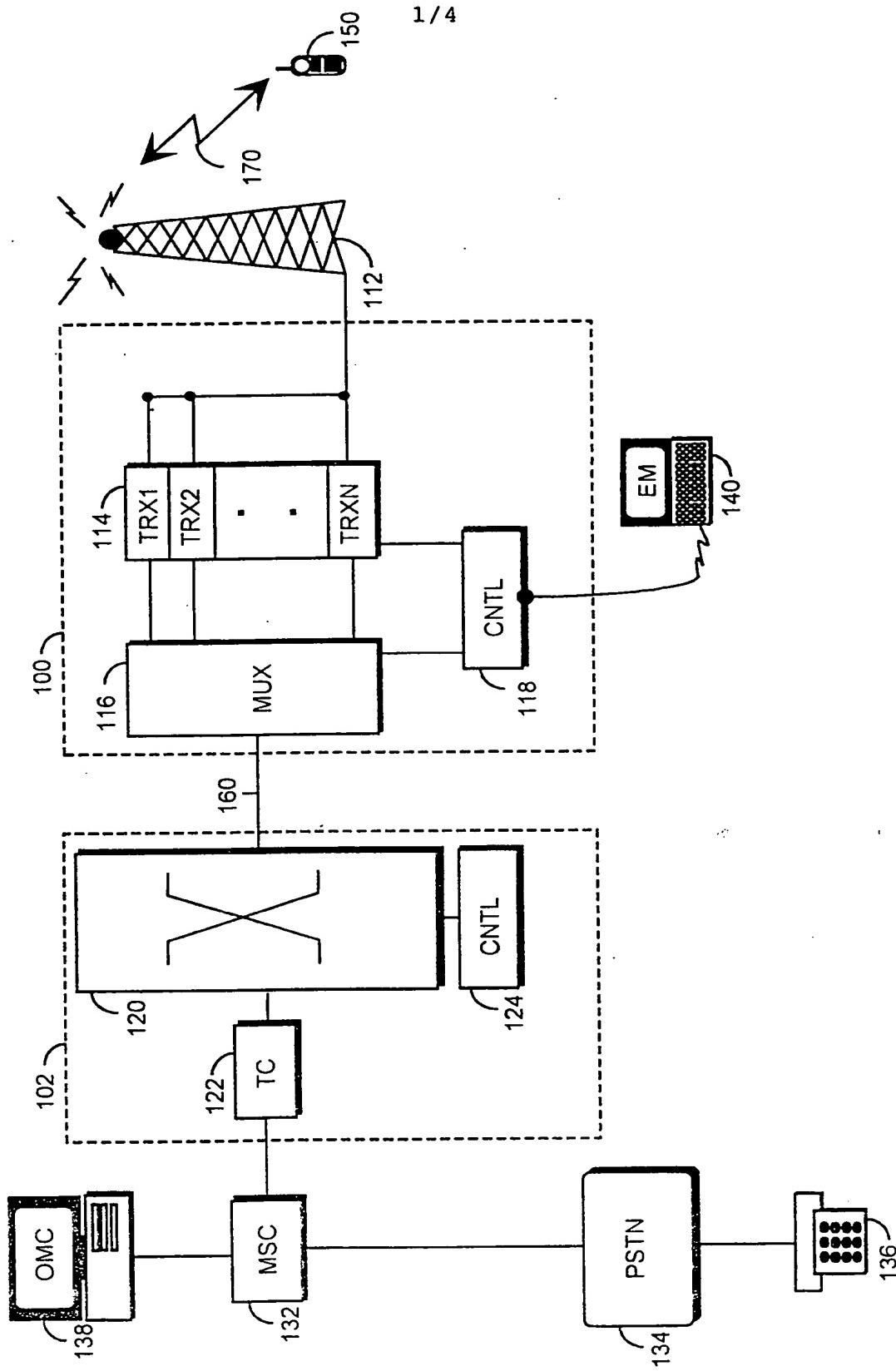


Fig 1

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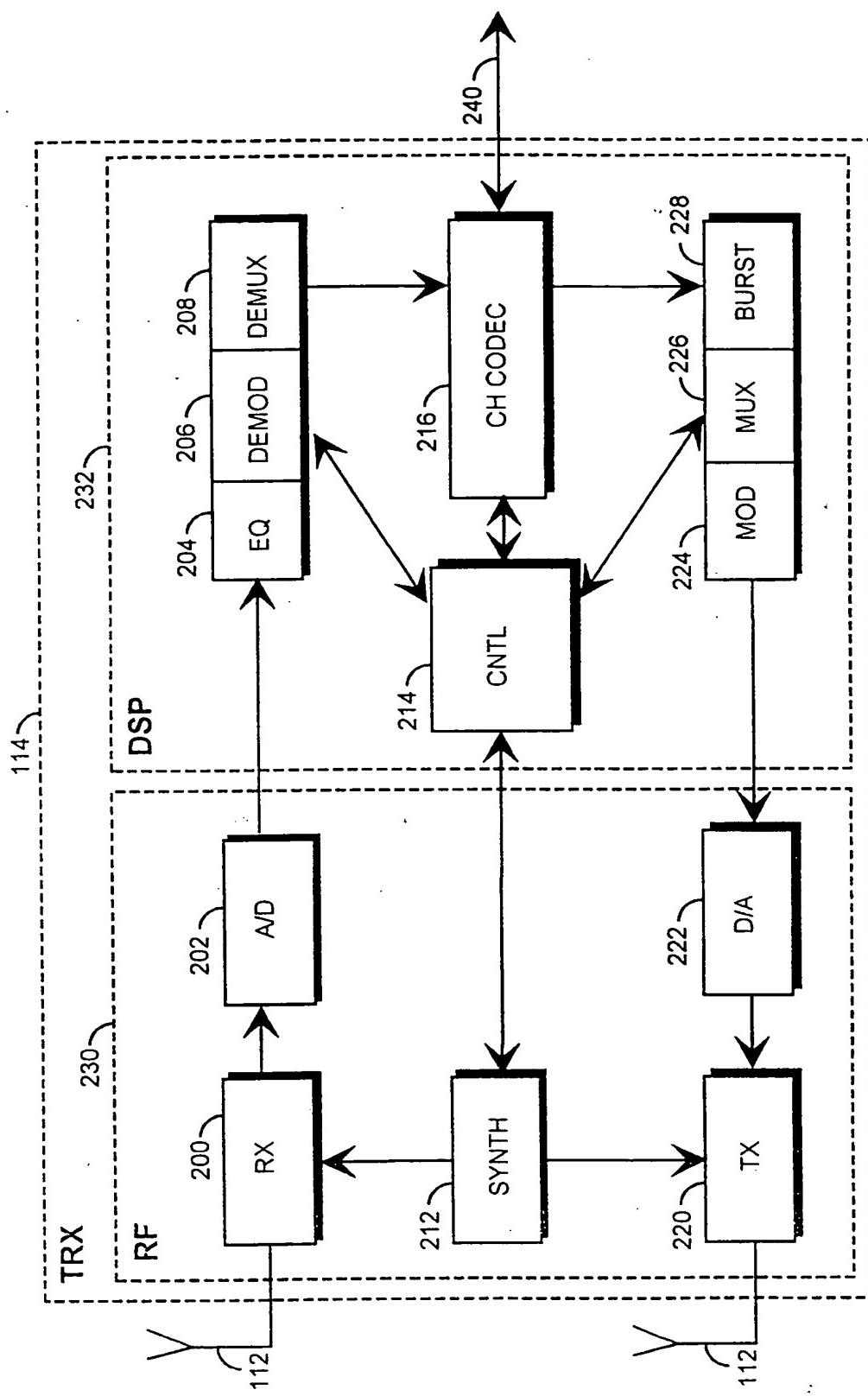


Fig 2

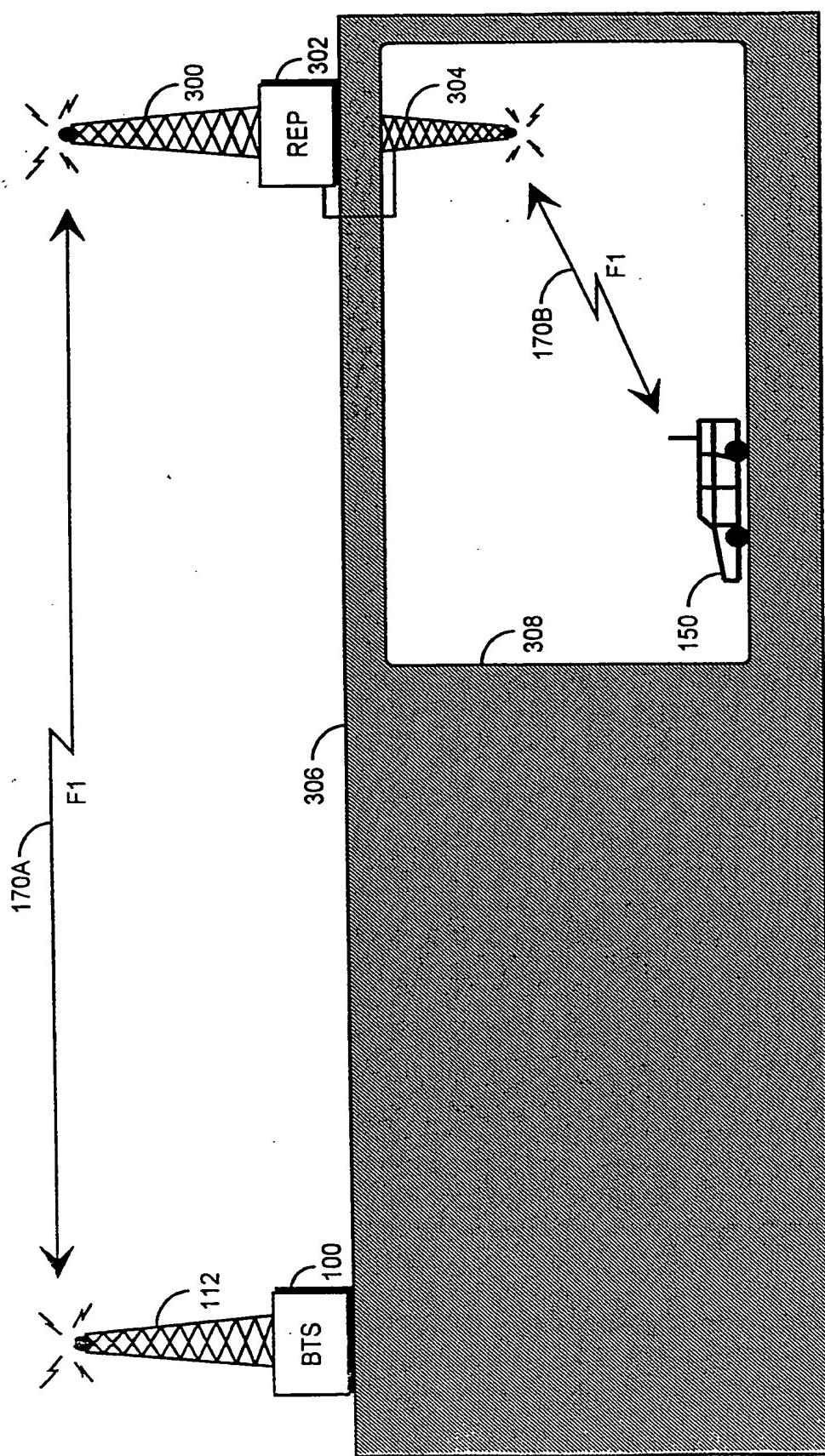


Fig 3

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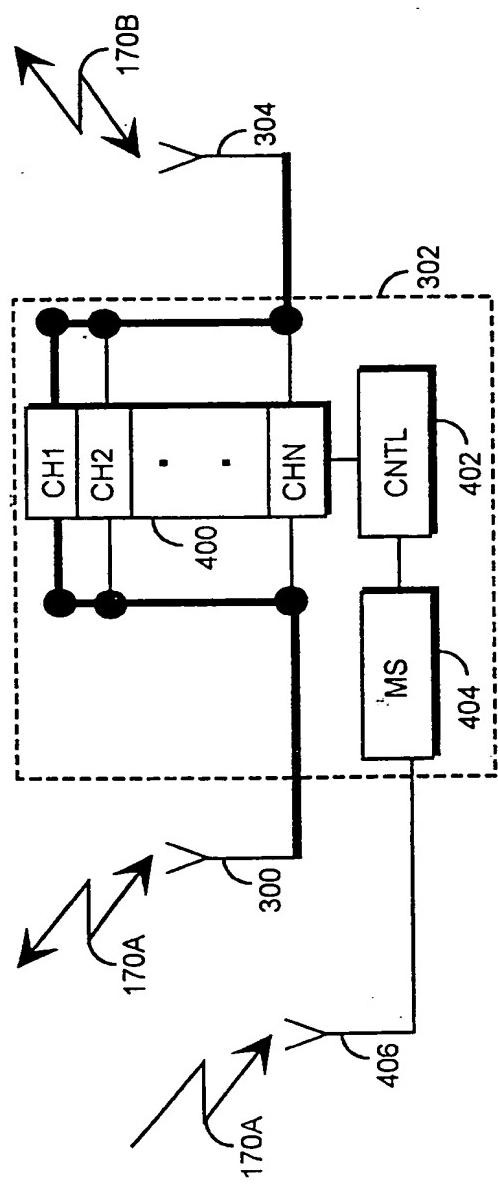


Fig 4

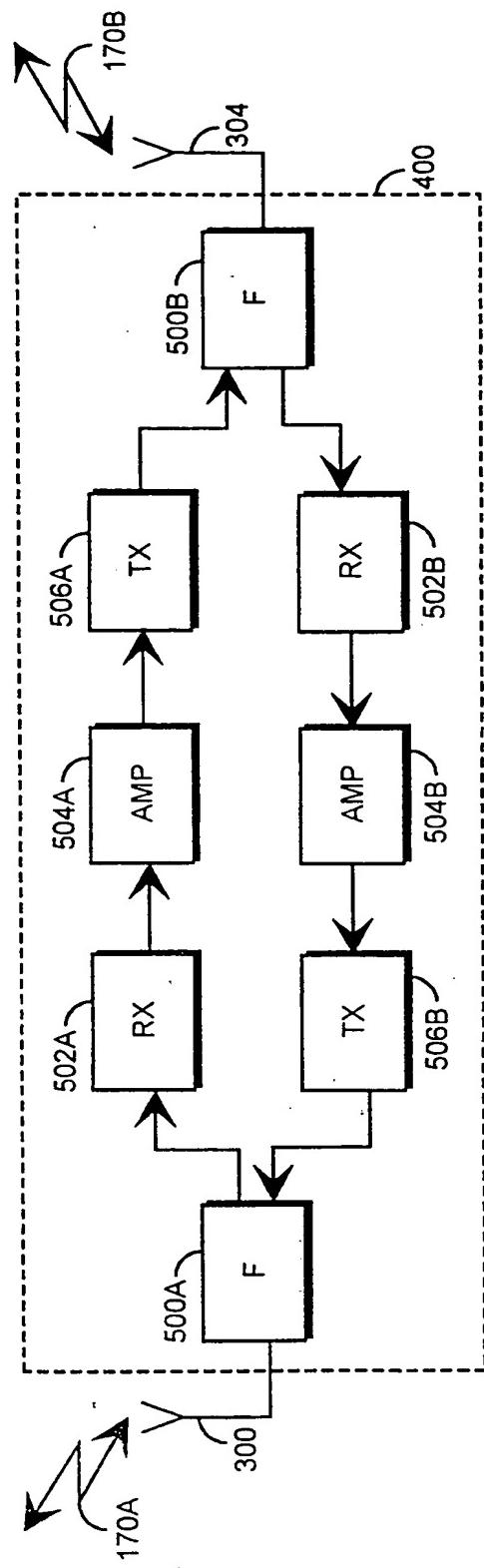


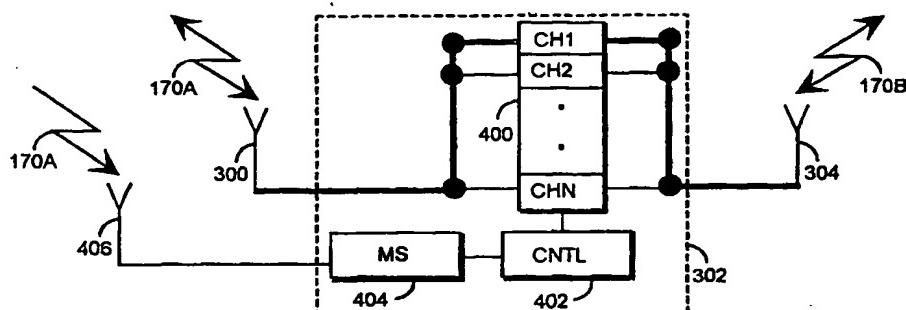
Fig 5



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/14, H04Q 7/38, H04B 17/02		(A3)	(11) International Publication Number: WO 99/17476
			(43) International Publication Date: 8 April 1999 (08.04.99)
(21) International Application Number: PCT/FI98/00775		(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).	
(22) International Filing Date: 30 September 1998 (30.09.98)			
(30) Priority Data: 973850 30 September 1997 (30.09.97) FI			
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<p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments. In English translation (filed in Finnish).</i></p>			
<p>(88) Date of publication of the international search report: 24 June 1999 (24.06.99)</p>			

(54) Title: METHOD OF ADJUSTING FREQUENCY OF CELLULAR RADIO REPEATER



(57) Abstract

The invention relates to a method of adjusting the radio frequency of a repeater (302) in a cellular radio network. The repeater (302) amplifies radio signals (170) of a bi-directional radio connection between a base station (100) and a subscriber terminal (150) at least at one particular radio frequency. In accordance with the invention, the repeater (302) monitors the radio signals (170) transmitted by at least one base station (100). The repeater (302) automatically tunes to amplify the signals (170) of the particular radio frequency on the basis of information included in the radio signals (170) it has monitored. The monitored radio signals (170) include a control channel, for example a broadcast control channel BCCH, comprising information on the operating frequencies of the base station (100). Monitoring means (404) are preferably similar to the subscriber terminal equipment (150).

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CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
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CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00775

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/14, H04Q 7/38, H04B 17/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5574788 A (J.S. CHILDRESS ET AL), 12 November 1996 (12.11.96), column 4, line 45 - line 60, claim 12, abstract --	1-11
X	GB 2242337 A (ROKE MANOR RESEARCH LIMITED ET AL), 25 Sept 1991 (25.09.91), see page 3, paragraph 3; page 4, paragraph 4; page 6, paragraph 2; page 7, line 1 - page 8, line 3; page 9, line 9 - line 11 --	1-11
A	US 5125102 A (J.S. CHILDRESS ET AL), 23 June 1992 (23.06.92), column 3, line 38 - line 47, abstract -- -----	1-11

Further documents are listed in the continuation of Box C.

See patent family annex.

- * Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" earlier document but published on or after the international filing date
- "C" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "D" document referring to an oral disclosure, use, exhibition or other means
- "E" document published prior to the international filing date but later than the priority date claimed
- "F" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "G" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "H" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "I&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 May 1999	07-05-1999
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Per Källquist Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

07/04/99

International application No.
PCT/FI 98/00775

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